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# Project Summary

# Assessment of Synthetic Membrane Successes and Failures at Waste Storage and Disposal Sites

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**Data from 27 lined facilities provided by five vendors is analyzed to determine the factors which contributed to success or failure of the liner at those facilities. The sites studied included a wide variety of wastes handled, liner types, geographic locations, facility ages, facility sizes, etc Based on the definitions used in this study, the 27 facilities selected by the vendors had a total of 12 "failures" at 10 sites. At four or five of these sites ground-water contamination apparently resulted from the failures.**

**Two main elements of success at lined sites are considered to be: (1) a proper philosophical and conceptual approach; and (2) the extensive use of quality assurance programs in all facets and stages of a facility's operation.**

**Three appendices are provided in the full report: Appendix A, Vendor Questionnaire; Appendix B, Vendor Summary Reports; and Appendix C, Summary Information on each site.**

***This Project Summary was developed by EPA's Hazardous Waste Engineering Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).***

## Introduction

This study was designed to supplement existing information on liner performance using an approach that involved an in-depth evaluation of the factors leading to both "successes" and "failures" at a limited number of case study sites.

A novel aspect of the approach used by Arthur D. Little, Inc., in its study was the use (under subcontract) of experts from companies (referred to as vendors) in the liner industry. Five such vendors agreed to provide information on lined facilities with which they had been associated. Each vendor was asked to select between 4 and 7 sites and to include both "successes" and "failures" within that group. Altogether, a total of 27 case histories were obtained; most of the sites selected by the vendors were waste impoundments of one kind or another, but not all would be considered hazardous waste sites.

Essentially all of the information provided to Arthur D. Little, Inc. by these vendors was in the form of a questionnaire response for each site (along with supporting drawings, design specifications, etc.) and a summary report. Vendors were asked to supply as much detail as possible, but were told that they were under no obligation to supply information that was not in their files or was not easily ascertainable. Data and summary reports on the 27 facilities supplied by the five vendors are analyzed in the full report.

## Approach

The general approach that was used to obtain and analyze the data on lined



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disposal sites and liner system performance involved five steps:

Step 1—Identification of, and preliminary negotiation with, prospective vendors;

Step 2—Design of questionnaire to be used (by vendors) for each site chosen;

Step 3—Issuance of subcontracts and instructions to vendors;

Step 4—Receipt of vendor reports and data preparation (by Arthur D. Little, Inc.), including computer encoding of textual answers to each question; and

Step 5—Review of all data and vendor reports (by several Arthur D. Little, Inc. technical specialists) to identify factors contributing to successes and failures.

It was agreed from the beginning that the identities of all vendors, as well as the identities of all site owners and other companies involved in work at the site, would be held confidential. This rule, and the use of Arthur D. Little, Inc. as an intermediary between the U.S. Environmental Protection Agency (EPA) and the vendors, made it possible for the EPA to benefit from the experience of the vendors without gaining access to proprietary (uncoded) information. The process also encouraged the vendors to provide detailed and honest assessments for their selected sites, especially if there had been problems.

## Overview of Sites in Survey

Table 1 provides summary information on the 27 liner sites for which data were collected. Table 2 provides summary information on the liner systems used at each site. The abbreviations used for the flexible membrane liners (FMLs) are as follows:

| Abbr. | Polymer Type | No. of Sites |
|---|---|---|
| CIM | Chevron Industrial Membrane (not a FML) (composition unknown) | 1 |
| CPE | Chlorinated polyethylene (OR = oil resistant) | 5 |
| HDPE | High density polyethylene | 7 |
| CSPE | Chlorosulfonated polyethylene | 6 |
| PO | Polyolefin | 1 |
| PVC | Polyvinyl chloride | 9 |

The suffixes (R) and (U) placed after the FML abbreviations in Table 2 stand for 'reinforced', and 'unreinforced', respec-

*Table 1. Summary Information on Liner Sites*

| Site ID | Site Location | Principal Activity at Site | Type of Lined Facility | Material Contained | Date Installed | Status (12/83) | Problems with Liner |
|---|---|---|---|---|---|---|---|
| V1-1 | South | Petroleum product storage | Reservoir | Oil field brine | 3/81 | Open | -- |
| V1-2 | South | Petrochemical storage | Reservoir | Oil field brine | 10/82 | Open | Yes |
| V1-3 | Southeast | Waste management | Landfill | Incinerator wastes | 11/80 | Open | -- |
| V1-4 | East | Waste management/ landfill | Landfill | Solid wastes | 9/80 | Open | -- |
| V1-5 | South | Chemical plant | Surf. Impd. | Liquid chemical wastes | 7/80 | Open | -- |
| V1-6 | East central | Chemical plant | Landfill | Solid wastes, chemicals | 6/81 | Closed | -- |
| V2-1 | South | Paper mill | Aeration basin | Wastewater | -/73 | Open | Yes |
| V2-2 | Midwest | Paper mill | Aeration basin | Wastewater, pulp liquor | 5/72 | Closed | Yes |
| V2-3 | West | Chemical plant | Surf. Impd. | Liquid, with salts | 3/71 | Open | Yes |
| V2-4 | East | Chemical plant | Landfill | Chemical process sludge | 8/74 | Open | -- |
| V3-1 | North | Dredge spoil disposal | Surf. Impd. | Dredge spoil | 4/83 | Open | Yes |
| V3-2 | North | Sanitary Landfill (type II) | Landfill | Solid waste (some chem.) | 7/77 | Open | Yes |
| V3-3 | Midwest | Wastewater treatment | Lagoon | Domestic sewage | 9/82 | Open | -- |
| V3-4 | North | Landfill | Landfill | Solid waste (munic. and ind.) | -/75 | Open | Yes |
| V3-5 | North | Paper mill | Surf. Impd. | Waste sludge and liquids | 9/82 | Open | -- |
| V4-1 | Canada | Uranium mining | Reservoir | Water, with metals, organics | 9/83 | Open | -- |
| V4-2 | South | Petroleum refinery | Reservoir | Oil field brine | 11/83 | Open | -- |
| V4-3 | Southwest | Electric power plant (coal) | Evap. pond | Wastewater | 8/83 | Open | -- |
| V4-4 | North | Waste management/ landfill | Landfill | Drummed chemical wastes | 7/82 | Open | -- |
| V4-5 | East | Waste management/ disposal | Lagoons | Landfill leachate | 12/80 | Open | -- |
| V4-6 | East | Chemical plant | Lagoons | Liquid chemical wastes | 6/80 | Open | -- |
| V4-7 | West | Electric power plant | Surf. Impd. (8) | Water; wastewater; flyash | 9/81 | Open | -- |
| V5-1 | West | Petroleum refinery | Surf. Impd. (4) | Process Liquids | 10/80 | Open | Yes |
| V5-2 | Soutwest | Uranium mill | Surf. Impd. | Wastewater | 6/79 | Open | Yes |
| V5-3 | West | Petroleum refinery | Surf. Impd. | Liquids | 8/78 | Closed | -- |
| V5-4 | West | Nat. gas compressor station | Surf. Impd. | Cooling tower blow down | -/74 | Open | Yes |
| V5-5 | West | Chemical plant | Surf. Impd. | Process water (with organics) | -/74 | Open | -- |



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tively. A reinforced FML is one that incorporates (usually bonded between two polymer sheets) an open fabric or scrim, typically made of polyester or nylon. HDPE and PVC liners are usually not reinforced, while CSPE and, to a lesser extent, CPE are usually reinforced.

All of the FMLs commonly used today to line waste treatment or disposal sites are well represented by the sites selected for this study.

## Categories of Failure

In evaluating lined facility case studies it is important to have a thorough understanding of the various ways in which a liner may fail. First, there is the problem of defining "failure" in a practical manner. In a strict sense, one might limit the scope to *ultimate failure* of the liner, i.e. events that are directly related to leakage of fluids through the liner. Examples would include punctures, tears, and/or seam failures in critical sections of the liner system. Ultimate failures, however, generally result from various stages of *preliminary failure* including, for example, poor materials, poor workmanship (especially during liner installation) and poor design. *Philosophical failures*, relating to a variety of misconceptions (about liners) and motives, also are potential forerunners of ultimate failures.

In the current study, no rigid classification scheme for failures was used (or really needed). However, two general types of failure that were differentiated were:

1. *Failure before operation*: This is defined as a condition of the liner which required *non-routine* corrective measures to make the liner suitable for use as designated (e.g., a tear or puncture caused by construction equipment).
2. *Failure during operation:* This is defined as a condition of the liner which causes (or threatens to cause) ground-water contamination, or which otherwise causes operations to cease because of observed abnormalities (e.g., "whalebacks," algal curl, preliminary chemical attack).

Success is defined as the converse of failure, i.e., non-routine corrective measures are not required, the liner does not leak, and operations are not shut down.

## Evaluation of Failures at Study Sites

There were twelve problems, at ten sites, described in the vendors' reports that fit the definition of "failure" described in the previous subsection. Table 3 provides a summary description of these failures and the apparent reasons for them based on the data in the vendor reports. As a consequence of these failures, pollutants were apparently released to the environment (i.e., the soil-ground-water system under the site) at

***Table 2.*** *Summary Information on Liner Systems*

| Site ID | Single (S) or Double (D) Liner | Primary Liner Material* | Primary Liner (mil) | Total Surface Area (ac) | Exposed (E) or Buried (B) | Monitoring System | Layers in Liner System** (bottom to top) | Air Vents | Problems with Liner |
|---|---|---|---|---|---|---|---|---|---|
| V1-1 | S | OR-CPE (R) | 36 | 10 | B | No | Gr/GeoTex/S&G/GeoTex/FML/ Soil cement | Yes | -- |
| V1-2 | S | CSPE (R) | 36 | 22 | E | Yes | Comp Clay/S/FML | Yes | Yes |
| V1-3 | S | PVC (U) | 30 | 2 | B | No | Lime Rk/S/FML/S/Lime Rk | No | -- |
| V1-4 | S | PVC (U) | 30 | 10 | B | No | Comp Soil/FML/Soil | No | -- |
| V1-5 | D | PVC (U), CSPE (?) | 20, 36 | 1 | E | Yes | Comp clay/S/FML/S/FML | Yes | -- |
| V1-6 | S | PVC (U) | 30 | 2 | B | No | Old Fill/Clean fill/FML/clay | Yes | -- |
| V2-1 | S | CSPE (R) | 30 | 120 | E | No | Comp clay and limestone/FML | Yes | Yes |
| V2-2 | S | CSPE (R) | 30 | 8 | E | No | Comp soil/S&G/FML | No | Yes |
| V2-3 | S | CSPE (U) | 30 | 2.3 | E | No | Comp Sub-base/FML | No | Yes |
| V2-4 | S | CSPE (R) | 30 | 4.3 | B | Yes | Comp Fill/FML/S/G | No | -- |
| V3-1 | S | PO (R) | 30 | 42 | B | Yes | Prepared limestone/FML/Stone | No | Yes |
| V3-2 | S | PVC (U) | 20 | 75 | B | Yes | Comp Clay/FML/S | No | Yes |
| V3-3 | S | PVC (U) | 20 | 8 | B | No | Comp Soil/FML/S | No | -- |
| V3-4 | S | Soil Sealant | 4 in. | 25 | B | Yes | Comp Sand/Liner/S | No | Yes |
| V3-5 | S | Asphalt-concrete | 5 in. | 2 | E | Yes | Comp. Soil/Asphalt (2 lifts) | No | -- |
| V4-1 | S | HDPE (U) | 100 | 18 | E | Yes | Comp Sand/FML | No | -- |
| V4-2 | D | HDPE (U) | 100 | 18.5 | E | Yes | Comp Clay/S/FML | Yes | -- |
| V4-3 | S | HDPE (U) | 80 | 88 | E | No | Comp Subgrade/FML | Yes | -- |
| V4-4 | D | HDPE (U) | 80 | 6 | E (sides) | Yes | Clay/S/Comp Soil/FML/Comp Soil | Yes | -- |
| V4-5 | D | HDPE (U) | 80 | 3.2 | B | Yes | Comp clay/FML/Comp clay | No | -- |
| V4-6 | S | HDPE (U) | 100 | 0.3 | E | Yes | Comp Soil/FML | No | -- |
| V4-7 | S | HDPE (U) | 80 | 66 | E (sides) | No | Subgrade/FML/S (bottom only) | No | -- |
| V5-1 | 3D, 1S | CPE (U), CPE (U) | 20, 30 | 1, 5 | E (CIM only) | Yes | Subgrade/CPE/Soil/Concrete/CIM | No (?) | Yes |
| V5-2 | S | CPE (U)/PVC (U) | 20/10 | 13 | B | Yes | Nat. Soil/FML/Nat. Soil | No | Yes |
| V5-3 | S | CPE (U) | 30 | 0.7 | B | Yes | Nat. Soil/FML/Nat. soil/soil cement | No | -- |
| V5-4 | D | PVC (U) | 20 | 1.4 | B | Yes | Comp Soil/Clay/S/FML/Nat. Soil | No (?) | Yes |
| V5-5 | Triple | 2xCPE (R), PVC (U) | 30, 20 | 0.75 | E | Yes | Comp fill/CPE/G/PVC/CPE/? | No (?) | -- |

* *See text for explanation of terms.*

***Comp = compacted; FML = flexible membrane liner; G = gravel; GeoTex = geotextile; Gr = ground; Nat = natural; rk = rock; S = Sand*



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*Table 3.* Summary Description of "Failures" at Case Study Sites

| Site ID | Nature of "Failure" | How Detected | Apparent Cause | Other Contributing Factors |
|---|---|---|---|---|
| V1-2 | Five holes found in liner caused by owner-operating personnel; minor brine loss | Monitoring well | Carelessness by owner-operating personnel | —Lack of clear operating procedures.<br>—Possible lack of concern (speculative). |
| V2-1 | Chemical attack of liner at liquid surface | Visual | Attack or dissolution by oil-based defoamer | —Use of oil-based defoamer not anticipated, thus not in original test program.<br>—Inadequate control of operations. |
| V2-2 | Whale-backs | Visual | Gas generation under liner; no allowance made for gas venting in design | —Inadequate study of soils and hydrogeology at site; presence of organic matter (in soil) had, however, been noted.<br>—Site used before for disposal of organic sludges. |
| V2-3 | Liner ripped | Visual | Tank truck slipped down slope | —No fence around site.<br>—Liner exposed. |
| V3-1 | (a) Holes and tears in liner | Visual | Liner placed between layers of coarse rock | —Poor design. |
| | (b) Escape of dredge material | Visual | Liner placed over coarse rock | —Poor control of operations.<br>—Poor communication between contractor, installer and engineer.<br>—Job awarded to low bidder (speculative). |
| | (c) Tear in liner panel | Visual | Waves entered construction area and scraped liner against dike | —Poor design (subgrade too coarse).<br>—Poor control during installation.<br>—Wet and windy weather. |
| V3-2 | Chemical pollutants showed up in collection drain water collected below liner | Leak Monitor | Apparent blockage of leachate collection drain; backup of leachate; movement through crack in liner (?) | —Poor bonding at seams, appurtenance (?)<br>—Poor control of installation practices; used "Honor Camp" youth to install FML.<br>—Undersized collection drain (?); due to poor design (?). |
| V3-4 | Pollutants showed up in monitoring wells around site | Monitoring well | Unknown; possible breakup of soil sealant liner | —Unknown; possible failure to fully test soil sealant for this type of application.<br>—Process for selecting liner unclear.<br>—No way to physically test liner once in use. |
| V5-1 | Liquids found in leak detector | Leak detector | Probable failure of sealing of concrete joints with PVC strips and spray-on liner, CIM | —Concrete installer, against explicit instructions, used curing compound that inhibited proper bonding of CIM to concrete.<br>—Poor design; improper information supplied on CIM; owner suggested use of CIM.<br>—Poor installation; lack of knowledgeable supervision. |
| V5-2 | Physical damage to liner prior to being put into service | Visual | Unknown, but suspect carelessness | —Questionable cooperation between contractors.<br>—Job awarded to low bidder (speculative).<br>—High winds and cold temperatures during construction (took 11 months!). |
| V5-4 | Fluid intrusion into monitoring well | Monitoring well | Membrane rupture at five, uniformly-spaced positions; tears probably by D-4 cat tractor used to spread soil cover over liner | —Operator of tractor let soil cover get too thin.<br>—Poor control of installation. |



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four or five sites (V1-2, V3-1, V3-2, V3-4, and V5-4), and one site was permanently removed from service (V2-2).

Other problems noted by the vendors, not all of which were connected with sites which had "failures," included the following:

- Installer had difficulty placing liner over geotextile fabric (V1-1);
- Inability to easily test degree of soil compaction in field (V1-3);
- Failure to conduct waste-liner compatibility tests (various sites);
- Indications that constructed facilities might be used for unplanned uses (thus not anticipated in the design) (V1-5);
- Gas generation between limestone and effluent; careful venting required (V2-1);
- Difficulty in repairing aged liner material (V2-1);
- Inadequate corrective measures taken due to desire for cheap solution (V2-2);
- One vendor reported problems with asphalt cracking (at other sites) in response to freeze-thaw cycles (see V3-5 data);
- Earthwork contractor had to be removed from job due to poor work (V4-2);
- Differential settlement in subgrade caused initial clay liner to crack (V4-5); and
- Mud and water in site caused difficulty in welding seams (V4-7).

## Evaluation of Successes at Study Sites

Finding the reasons for success is more difficult than finding the reasons for failure. Since success is the absence of failure, it is essentially asking why everything went right. Clearly, no one action can be credited with a resulting success as, by contrast, it could for a failure. More commonly, success will follow from an understanding of the potential problems associated with liner installation and use, and the subsequent planning to avoid as many problems as can reasonably be perceived in advance, and to quickly identify and correct other problems as they arise.

In providing a synthesis and independent evaluation of the apparent reasons for success at the study sites, we have developed several hypotheses which we believe are reasonable and consistent with the cases actually studied. There is, however, no way to prove the hypotheses based on the data gathered for these sites, but future case studies could be used to test them.

First, success is more likely to follow if the responsible individuals have the proper philosophical and conceptual approach. If they understand that what they are doing is important and that the process of designing, installing, and using a lined facility involves many technical factors that will likely present problems, then they are more likely to proceed with due diligence. A key element of the proper philosophical approach is: (1) to assume that there will be problems; (2) to examine the possible consequences of those problems and/or "failures"; and then (3) to take the appropriate steps (e.g., design changes, quality control procedures) to avoid or minimize the problems.

Second, this approach must be applied to all stages or facets of the liner system including:

- Liner system design
- Liner material selection
- Site preparation
- Liner installation
- Facility operation (including liner maintenance)
- Facility closure (for RCRA landfills requiring covers)

Within each of these areas, the generalized approach must be applied within the framework of a formal quality assurance (QA) program. It is worth noting that the vendors reported that at least 23 of the 27 sites had some sort of a quality assurance program; no data were provided on the other four sites. It is difficult to judge the coverage of the QA programs used in the study sites, but about 17 sites (each) specifically mentioned the use of a QA program for: (a) liner manufacture, (b) liner fabrication, and (c) liner installation. If a detailed QA program were developed and followed for each of the steps listed above, the "success" rate would likely be increased.

Finally, there are a number of more specific items that appear to be related to success and deserve special mention even if they are partly covered by good QA programs. These are listed under Conclusions, below.

## Conclusions

The nature of the "failures" noted included chemical attack of the liner (1 or 2 sites), physical tears or punctures (5 sites), problems with field seaming or other liner installation activities (1 to 3 sites), and large gas bubbles, called "whale-backs," under the liner (1 site).

Some of the contributing factors, if not causes, for the failures noted in our case studies include the following:

- Failure to control operations (at an operating site) so as to safeguard the liner;
- Poor (or inadequate) design work in general;
- Failure to use an independent, qualified design engineer;
- Poor (or inadequate) installation work in general;
- Poor (or inadequate) communication and cooperation between companies working on an installation job;
- The use of untrained and/or poorly supervised installers;
- Failure to conduct (or adequately conduct) waste-liner compatibility tests;
- Adverse weather conditions during installation;
- Use of old dump site, with contaminated soil, as site for lined facility;
- Selection of companies (for liner job) by processes that did not help ensure that good materials and workmanship would result;
- Selection of liner material by process not involving detailed bid specifications prepared by design engineer, not liner manufacturer); and
- Facility age (more failures were associated with the older sites).

Two main elements of success at lined sites are considered to be: (1) a proper philosophical and conceptual approach; and (2) the extensive use of quality assurance programs in all facets and stages of a facility's construction and operation. The desired philosophical approach requires that the responsible individuals (owner, designer, general contractor, installer, etc.) understand the importance of what they are doing and appreciate the complexities (and associated technical problems) that will be attended. A key element of this approach is: (1) to assume that there will be problems; (2) to examine the possible consequences of those problems; and then (3) to take the appropriate steps (e.g., design changes, quality control plans) to avoid or minimize the problems.

Success is also more likely to result if the general approach described above is



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applied to all stages or facets of a liner system including design, material and contractor selection, site preparation, liner installation, facility operation, and closure. Within each of these areas, the generalized approach should be applied within the framework of a formal quality assurance program.

Other factors noted as contributing to success included:

- Overdesign of a system;
- Presence of a knowledgeable customer;
- Bidding to specifications;
- Selection of qualified companies;
- Cooperation amongst companies on liner job;
- Conducting waste-liner compatibility tests;
- Simplicity of design; and
- Good weather.

## Recommendations

The purpose of this section is to provide a brief summary of what appear to be the most important areas for future work that will help ensure safe and reliable operations at lined RCRA facilities. Recommendations of four different types are included:

- Research projects
- Education
- Quality assurance; planning and implementation
- Preparation of guidance documents

### *Research Projects*

This study analyzes the factors which contribute to success and failure at lined facilities, but does not provide a statistical basis for determining the actual significance of these factors. A statistically valid study could be conducted using the experience gained in conducting the present study to verify the conclusions of the present study and quantify the significance of failure and success factors at liner sites. The study could address the following questions, among others:

- Are older facilities more likely to experience failure? By what mechanisms?
- Are larger facilities more likely to experience failure? By what mechanisms?
- How do QA/QC programs at various levels contribute to success?
- How are the various success and failure factors evident at sites which have experienced problems? At sites which have not experienced problems?
- What is the apparent "success" rate for FML installations of various types?
- How well do RCRA-designed sites perform in comparison with non- or pre-RCRA sites?

Only two sites in this study did not use a flexible membrane liner (FML) as the primary liner. Consequently, little was learned in general about the reasons for success and failure for other types of liners such as soil cement, asphalt, and spray-on. Additional research, including more case studies focusing on facilities with such liners, would be desirable.

Vendor V3 provided a number of more specific research recommendations covering such areas as seaming technology, leachate hydraulics, FML durability under hydraulic stress, long-term waste-liner compatibility tests, and an evaluation of accelerated leachate-liner compatibility tests. Vendor V1 suggested that development of a set of consistent quality standards for FMLs, and the development of test protocols by which related FML properties would be measured.

### *Education*

This report describes how important the proper philosophical and conceptual approach is to "success" for a lined site. To help foster the desired approach, a conscious effort should be made to *continue educating concerned parties* (industry, design engineers, installers, etc.) about the issues, problems, and solutions relating to the installation and use of lined facilities. This can be done by a variety of means including regional workshops, conferences where technical papers can be presented, and report publication. All of these are currently being done to some extent, and it is strongly recommended that education continue to be emphasized.

In addition to the above, it is recommended that the EPA prepare a special annotated bibliography of important reports and publications covering liners. A significant amount of information is available, but few people are generally aware of it. Newsletters (which could be distributed free or as part of recently initiated trade journals on geomembranes) that covered EPA activities related to liners would also be welcome.

### *Quality Assurance: Planning and Implementation*

Much higher assurance of success will be associated with facilities built and operated within the framework of one or more quality control or quality assurance (QA) programs. These programs should cover all stages of a facility's life: design, material selection, site preparation, liner installation (including thorough seam integrity inspection), facility operation and closure.

It is recommended that guidance in the preparation and implementation of quality assurance programs be prepared. This guidance should be as detailed as possible, and backed up by examples and the availability of technical consulting from the EPA or its contractors.

Preparation and use of QA plans should also be considered as a regulatory requirement for a RCRA permit.

### *Preparation of Guidance Documents*

The EPA has prepared over a dozen Technical Resource Documents (TRDs) as well as other reports providing guidance on many aspects of hazardous waste treatment, storage, and disposal. This study showed that such documents are very important for lined installations, and that guidance documents should be prepared or updated to cover (or expand their coverage on) subjects such as the following:

- Operating procedures that safeguard the liner system;
- Writing bid specifications for liner materials or installations;
- Best use of geotextiles in liner systems;
- Methods to evaluate potential for gas generation in subsoils;
- Acceptability of using old disposal areas for new RCRA sites;
- Obtaining coordination and cooperation from the several companies involved in a liner job;
- Sealing FMLs around appurtenances;
- Specifications for selection and preparation of subgrade materials to be used under FMLs; also need to describe methods to test this subgrade (after placement) for proper density and moisture content; and
- Methods to test the completeness of seam closures in a liner installation.



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*The complete report, entitled "Assessment of Synthetic Membrane Successes and Failures at Waste Storage and Disposal Sites," (Order No. PB 85-245 637/AS; Cost: $16.95, subject to change) will be available only from:*
*National Technical Information Service*
*5285 Port Royal Road*
*Springfield, VA 22161*
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